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INVESTIGATION OF THE GUYANDOT RIVER
BASIN. REPORT ON BENEFITS TO WATER
SUPPLY AND POLLUTION ABATEMENT FROM
LOW FLOW AUGMENTATION ON THE
GUYANDOT RIVER AND TRIBUTARIES

Public Health Service
Charlottesville, Virginia

February 1960

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INVESTIGATION OF
THE GUYANDOT RIVER BASIN

Report on Benefits to Water Supply and Pollution
Abatement from Low Flow Augmentation on the
Guyandot River and Tributaries

Prepared at the request of and in cooperation with
the District Engineer, Huntington District
Corps of Engineers, U. S. Army

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Bureau of State Services
Division of Water Pollution Control

Region III, Charlottesville, Virginia
Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

February 1960

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The conduct of an investigation of this type depends to a large extent upon the cooperation of other Federal agencies, and State and local authorities in the region studied. This investigation was aided materially by the extensive cooperation and assistance of such agencies and authorities located in or having jurisdiction over matters relative to the Guyandot River Basin.

Detailed information on the reservoir proposals and various hydrological and territorial data required in the study were supplied by the U. S. Army Engineer District, Huntington Corps of Engineers.

The West Virginia State Water Resources Commission contributed information on water pollution and pollution control requirements; and the West Virginia Department of Health provided water supply data and information on legislation relative to the evaluations.

Invaluable information was obtained from city officials and water plant operators concerning local water supply and treatment problems in the Guyandot Basin.

INTRODUCTION

the This report presents the results of an investigation made by the Public Health Service in connection with several proposals for water storage in the Guyandot River Basin of West Virginia. *the* This study was made at the request of the District Engineer, Huntington Corps of Engineers, dated April 17, 1959. Information is presented on water supplies, pollution sources, and water quality in the Guyandot Basin as obtained during a field investigation from April 28 to May 8, 1959. Also presented is an evaluation of water supply and pollution abatement benefits that could accrue by providing increased flow from various proposed reservoirs during periods of low natural stream flow. *end*

The needs for assured supplies of surface water during drought periods are discussed and considerations relative to general public health, recreation, and industrial development values are given.

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SUMMARY

1. Coal washery wastes constitute the major source of stream pollution in Guyandot Basin streams, although steady improvements have been made in recent years through control measures set forth by the West Virginia State Water Resources Commission.
2. Approximately 50 per cent of the Guyandot River is seriously polluted by untreated domestic sewage.
3. Essentially no use is made of the Guyandot River for recreation.
4. Fishing has been nearly eliminated in the main stem of the Guyandot River as a result of pollution. Fishing is termed "fair" for limited kinds of fish in Mud River.
5. Approximately 75 per cent of the basin populations are served by water systems taking water from wells and abandoned mines with the balance served by systems taking water from surface sources.
6. Ground water in the Guyandot Basin contains iron averaging 9.5 parts per million and hydrogen sulfide as high as 20 parts per million, making treatment of these waters difficult and expensive.

7. Most of the ground water supplies serving small communities and coal camps deliver water of inferior quality for domestic use.
8. From the standpoint of raw water quality and costs to produce water of acceptable quality for domestic purposes, surface water is the most desirable and economical source in the Guyandot Basin.
9. Stream flows are not dependable as a source of water for municipal or industrial use in approximately 80 per cent of the Guyandot Basin.
10. Assured increases in stream flow during low flow periods would be required in order to meet demands by communities or groups of communities desiring to use surface water as a source of supply.
11. For the Guyandot River to be used as a source of water supply in areas where this source is needed to replace low quality ground water, this would require that sewage treatment with effluent chlorination be provided at Mullens and Pineville, West Virginia.
12. To assure dissolved oxygen concentrations no lower than 4.0 parts per million in all reaches of the Guyandot River and tributaries during low flow periods, waste treatment at all sources combined with low flow augmentation is required.
13. Flow increases totaling 92 and 46 cfs from 10 proposed upper basin reservoirs would provide annual benefits to water supplies in terms of savings in treatment costs and cost of a single purpose reservoir

of \$185,000 and \$149,300, respectively. Annual pollution abatement benefits in terms of equivalent costs of sewage treatment provided by these increases would be \$85,700 and \$74,600, respectively, between the years 1960 and 1975 and \$14,400 for both increases between the years 1976 and 2010.

14. Flow increases of 200 and 100 cfs from a main stem dam near Baileysville would provide benefits to water supplies in terms of savings in treatment costs and cost of a single purpose reservoir of \$102,600 annually for both flow increases. Annual pollution abatement benefits for each of the increased flows in terms of equivalent sewage treatment costs would be \$74,600 between the years 1960 and 1975 and \$10,400 between the years 1976 and 2010.

15. Flow increases of 100 and 50 cfs from a reservoir on Mud River upstream from Milton would provide benefits to water supply in terms of a single purpose reservoir of \$7,300 for both flow increases. Annual pollution abatement benefits in terms of equivalent sewage treatment costs for each flow increase would be \$30,500 between the years 1960 and 1975 and \$2,400 between the years 1976 and 2010.

16. Flow increases totaling 36 cfs from Tommy Creek, Pinnacle Creek, Laurel Fork Creek, and Indian Creek would provide annual benefits to water supplies in terms of savings in treatment costs and cost of a single purpose reservoir of \$173,400. Annual pollution abatement benefits in terms of equivalent sewage treatment costs provided by this flow increase would be \$69,300 between the years 1960 and 1975, and \$14,400 between the years 1976 and 2010.

17. Flow increases totaling 26 and 20 cfs from Tommy Creek, Pinnacle Creek and Indian Creek would each provide benefits to water supplies in terms of savings in treatment costs and cost of a single purpose reservoir of \$173,400 annually. Annual pollution abatement benefits in terms of equivalent costs of sewage treatment provided by these increased flows would be \$62,500 and \$56,800, respectively, between the years 1960 and 1975, and \$14,400 for both flow increases between the years 1976 and 2010.
18. Flow increases totaling 14 cfs from Pinnacle Creek and Indian Creek would provide benefits to water supplies in terms of savings in treatment costs and cost of a single purpose reservoir of \$98,400 annually. Annual pollution abatement benefits in terms of sewage treatment cost equivalents provided by this flow increase would be \$43,400 between the years 1960 and 1975 and \$14,400 between the years 1976 and 2010.
19. Assured increases in stream flow for water supply and pollution abatement purposes during low flow periods could be invaluable in promoting municipal and industrial growth in the Guyandot Basin.
20. Restoration of fishlife and improvements in stream water quality by pollution abatement measures would provide significant recreational values in the Guyandot Basin.
21. Any increase in flow to the Ohio River during low flow periods would provide intangible benefit in terms of improved quality over and above minimum objectives.

22. In addition to tangible benefits from increased flows within the Guyandot Basin, a small tangible benefit resulting from reductions in the use of chemicals required for treatment of water and waste in the Cincinnati-Covington area would be realized.

AREA 22

The Guyandot Basin, comprising an area of 1,000 square miles, is located in the southwest of southwestern West Virginia. It is an important coal mining area and is situated in the Big Sandy River Basin which flows to the south. The Guyandot River has its source near Hinton, West Virginia, in the southern portion of Raleigh County as the confluence of the Guyandot and Big Sandy Rivers. It flows in a westerly direction approximately 100 miles to the town of Gilbert, West Virginia, where it joins the Ohio River. The basin is composed of rugged mountainous country which covers the south of West Virginia, representing 1.5 per cent of the surface area of the State. There is but one major tributary, the Big Sandy River, which flows 100 square miles and enters the Guyandot River at Hinton, West Virginia. The river and many upper basins tributaries within the heavily populated and industrial area of the city of Huntington, West Virginia, is tributary to the Guyandot at and just above the mouth.

DESCRIPTION

THE AREA

The Guyandot Basin, comprising an area of 1,670 square miles, is located in the mountains of southwestern West Virginia. It is an important coal mining area and is similar to the Big Sandy River Basin which lies to the west. The Guyandot River has its source near Rhodell, West Virginia, in the southern portion of Raleigh County at the confluence of Winding Gulf and Stone Coal Creeks. It flows in a westerly direction approximately fifty miles to the town of Gilbert, West Virginia, where it turns north and continues for 115 miles emptying into the Ohio River at Huntington. The Guyandot Basin is composed of rugged mountainous country wholly within the State of West Virginia, representing 6.88 per cent of the surface area of the State. There is but one major tributary--the Mud River--which drains 358 square miles and enters the Guyandot from the east at Barboursville, seven miles above its mouth. The river and many upper basin tributaries drain the heavily populated and important coal mining areas in Logan, Wyoming, and part of Raleigh Counties. The eastern portion of the City of Huntington, West Virginia, is tributary to the Guyandot at and just above the mouth.



GUYANDOTTE RIVER BASIN AND PROPOSED DAM SITES

HYDROLOGY

The flow of the Guyandot and Mud Rivers has been measured by the United States Geological Survey since 1915. Currently there are three gauging stations, two of which are on the main stem at Man and Branchland; and the other on the Mud River, 3.4 miles south of Milton. For 27 years of record the average discharge of the Guyandot at Man and Branchland is 962 and 1,523 second feet, respectively. The maximum and minimum daily discharge known at Man as of 1956 was 40,000 and 3.0 second feet, respectively; and at Branchland, 43,500 and 3.6 second feet, respectively. The average discharge at the Mud River gauge for 18 years of record is 274 second feet. Maximum and minimum discharges at the Mud River gauge are 14,500 and 0.1 second feet, respectively.

POPULATION AND INDUSTRIAL STATISTICS

According to the 1950 census, approximately 8.4 per cent of the population of West Virginia (2,005,552 persons) reside in the Guyandot Basin. The majority (approximately 70 per cent) of the basin population resides in small unincorporated communities and coal camps along the Guyandot River and tributaries with the balance located in corporate and metropolitan areas. There are approximately 56 coal mines, seven natural gas compressor stations, and 15 railroad yards in the basin. In addition, the International Nickel Company has a plant in the basin and there is one steam-electric power plant located at Logan.

WATER RESOURCES

Approximately 84 domestic water supplies exist in the Guyandot Basin. Seventy-two of these are supplied from wells, springs, and abandoned mines, and twelve supplies use surface water from the Guyandot River and various tributary streams. Surface water supplies serve approximately 40,000 persons or 25 per cent of the basin population. Consumption of surface water for domestic use is approximately 2.2 mgd. Industrial water use, other than that used for coal washing, averages about 8 mgd of which compressor stations use 4.3 mgd; International Nickel Company, 2.2 mgd; and the railroads, 1.25 mgd. The Appalachian Power Plant at Logan uses an average of about 136.8 mgd.

Water for washing coal is obtained mainly from springs, wells, and abandoned mines. It is estimated that the quantity of water used by the coal industry in the Guyandot Basin is 20-25 mgd.

The major use of the Guyandot River and tributaries is for disposal and transport of silt and coal fines from coal washing operations. Several sections of the river and tributaries are also used for

the disposal of domestic sewage and waste refuse. There is very little fishing or water recreation in the Guyandot Basin due to the heavy suspensions of coal wastes in the waterways.

Approximately 84 domestic water supplies exist in the Guyandot Basin. Seventy-two of these are supplied from wells, springs, and cisterns, and twelve supplies use surface water from the Guyandot River and various tributary streams. Surface water supplies serve approximately 40,000 persons or 25 per cent of the basin population. Consumption of surface water for domestic use is approximately 2.5 mgd. Industrial water use, other than that used for coal washing, averages about 8 mgd of which compressor stations use 4.5 mgd; International Nickel Company, 2.5 mgd; and the railroads, 1.5 mgd. The Appalachian Power Plant at Logan uses an average of about 150.5 mgd. Water for washing coal is obtained mainly from springs, wells, and abandoned mines. It is estimated that the quantity of water used by the coal industry in the Guyandot Basin is 20-25 mgd. The major use of the Guyandot River and tributaries is for disposal and transport of silt and coal fines from coal washing operations. Several sections of the river and tributaries are also used for

POLLUTION SOURCES

The West Virginia State Water Resources Commission estimates that 56 washeries each producing 500 tons of washed coal per hour would produce 20,000 tons of solids per day. Progress is being made through efforts by the West Virginia State Water Resources Commission and cooperation of mining companies in reducing washery waste pollution. At many mining sites waste treatment is accomplished by sedimentation and storage of the removed solids in the vicinity of the washery operation. It was observed, however, that in many instances during heavy rains, "slugging" of adjacent streams with solids from improperly contained storage piles occurs. This condition, together with the "flushing" of deposited solids from the stream bed during rising stream stages, is reported to interfere substantially with the operation of water treatment plants taking these waters for municipal use downstream. Under normal flow conditions it appears that the quantities of coal fines and silt contained in surface waters used for municipal purposes are removed rather successfully by coagulation, sedimentation, and filtration, although greater time and expense is involved than would be expended were the waters void of these polluting substances.

The discharge of domestic sewage to the Guyandot River and tributaries is uncontrolled. Approximately 43,000 persons are served by urban sewerage systems in the Guyandot Basin. Only one community--Hamlin, West Virginia, on the Mud River--has a sewage treatment facility. This facility, an Imhoff type tank, is reported to be grossly overloaded.

Approximately 50 per cent of the sewage load discharged to the water courses of the Guyandot Basin occurs within the corporate limits and greater metropolitan area of Logan, West Virginia. All other sewered populations are located at 18 communities having complete or partial sewerage systems ranging from 140 to 2,100 persons served. Of the 12 public water supplies taken from surface sources, five are from streams receiving sewage from one or more communities above the water intake.

In addition to domestic sewage received in the streams of the Guyandot Basin, there are a number of industries in the Huntington area discharging untreated wastes directly or through the city system to the Guyandot River. It has been reported that on occasion the surface water supplies, particularly at Man, West Virginia, are adversely affected by "mud wastes" and high chlorides originating from gas well pumpage at various upstream compressor stations.

WATER QUALITY

The entire length of the Guyandot River and many tributaries contain "black water" resulting from the solids material discharged from coal washeries. At Logan, the turbidity of the water ranges from 100 to 5,000 ppm. At times of low flow, thick deposits of coal fines and silt are visible along the banks and bottom of the river. Little, if any, aquatic bottom life exists and only German catfish may occasionally be caught where at one time bass fishing flourished. Prior to the recent action taken by many mining companies to reduce washery waste pollution the condition of the streams had continually worsened since about 1940 when higher grade coal was first demanded by coal-using industries. According to stream sampling by the State of West Virginia in 1947 and 1948, the quality of about 50 per cent of the Guyandot River was found unsuitable for water supply use, recreational use, or as a habitat for the normal propagation of fish life. The river and several tributary streams in the upper half of the basin were drastically polluted as evidenced by coliform organisms originating in domestic sewage. To an even greater degree, deposits of coal sludges on the stream bed added to the generally poor condition.

The major tributaries possessing serious pollution characteristics were Winding Gulf and Stone Coal Creeks above Mullens; Buffalo Creek at Man; and Island Creek in the Logan area. Island Creek, which drains a large portion of the western half of Logan County, appeared to be the most seriously polluted stream in the basin. High biochemical oxygen demands, low dissolved oxygen, high coliform concentrations, solids, color, acidity, and unsightly appearance characterized the degree to which this stream and its tributaries were polluted. It was recently observed that the lower three miles of Barkers Creek, below Mullens, is now grossly polluted by coal washery wastes, but that an improvement in the condition of Stone Coal and Slab Fork Creeks has taken place.

The Mud River, by virtue of its location in the lower agricultural section of the basin, is said to be "seldom clear." The nature of the soils and extent of land cultivation in this watershed are believed responsible for the turbid condition. Much of Mud River is unsuited for water supply and recreational uses owing to high concentrations of coliform organisms. Although the Mud River receives sewage from Hamlin and Milton, it is believed that the coliform organisms and biochemical oxygen demand originate to a large extent from agricultural sources. Fish life in Mud River is termed "fair" for limited kinds of fish by the Fish Management Division of the Conservation Commission of West Virginia.

Serious pollution of the Guyandot River occurs in the Huntington area prohibiting any reasonable use of these waters. Sewage and industrial waste discharges cause a substantial increase in biochemical oxygen demand and numbers of coliform organisms in these waters.

The operators of water plants taking surface waters for municipal use, report the water to be generally moderate in salts contributing to hardness (rarely exceeds 150 ppm hardness, usually about 90 ppm), and that the pH (acid-base index) ranges between 6.5 and 7.5 (pH 7.0 - neutral).

Ground water in the Guyandot Basin serves as the supply for about 75 per cent of the basin population. Analyses made on eight well water supplies by the State Health Department of West Virginia, showed the ground water to contain concentrations of iron ranging from 0.6 to 29.0 ppm with an average of 9.5 ppm. The Public Health Service recommends that water delivered to distribution systems not exceed 0.3 ppm of combined iron and manganese.¹ Concentrations of hydrogen sulfide as high as 20 ppm in ground water have been reported. The hardness of ground water is variable ranging from 80 to 600 ppm. Treatment of water containing hardness in excess of 150 ppm is generally considered justified. The pH of ground water ranges between 6.5 and 8.0, although in isolated instances acid waters with a pH of 3.0 exist.

Abandoned mine water is similar to well water in pH and hardness but appears to contain less iron. Seven mine water supplies tested by

the State Health Department of West Virginia contained iron varying from 0.0 to 18.0 ppm. Five of these supplies contained less than 1.0 ppm of iron, and two others contained 4.0 and 18.0 ppm of iron, respectively.

The relative cost of treating surface and ground water for municipal use is shown in a later section dealing with water supply benefits.

PROPOSED WATER STORAGE

RESERVOIR SITES

In order to develop the most favorable plan or plans for water storage in the Guyandot Basin, seven combinations of reservoirs and flow increases are evaluated. For reference purposes in later discussions, the reservoirs and flow increase proposals are designated as Plans I through VII.

Plan I consists of ten proposed reservoir sites located on eight tributary streams in the upper Guyandot Basin which together would control about one-eighth of the total basin drainage. Plan II consists of one main stem reservoir also located in the upper portion of the basin, controlling drainage from approximately one-third of the basin. Plan III involves one reservoir on Mud River which would control about three-fourths of this tributary, or one-sixth of the drainage from the Guyandot Basin. Plans IV to VII involve various combinations of reservoirs and flow increases among those proposed in Plan I.

LOW FLOW AUGMENTATION

The estimated maximum increase in flow from the ten proposed tributary reservoirs included in Plan I would provide a combined flow increase of 92 cfs. Plan II would provide a maximum increase of 200 cfs below the proposed main stem reservoir; and the Mud River proposal, Plan III, would add 100 cfs downstream from this particular proposed site. Each of Plans I, II, and III are evaluated on the basis of full augmentation and one-half augmentation. The increases in flows provided by Plans IV through VII range from 36 to 14 cfs. Table 1 shows the locations of proposed reservoirs included in each of the seven plans together with river mileages, drainage areas, and flow increases.

Table 1

Reservoir Locations, Drainage Areas, and Estimated Flow Increases
Plans I - VII

Plan No.	Location of Proposed Dam	Miles From Mouth Guyandot River	Drainage Area At Dam (sq.mi.)	Drainage Area At Mouth (sq.mi.)	Est. Increase (cfs)	Accum. Total Inc. (cfs)
I						
	Tommy Creek	162, 2	13.8	14.9	6.0	
	Barkers Creek	154, 5	15.5	37.6	7.0	13
	Cabin Creek	149		13.1		
	Marsh Fork Black Fork	149, 4, 1 149, 4, 1	3.7 2.7		1.5 1.5	16
	Pinnacle Creek	144, 2	55.9	58.8	23.0	39
	Rockcastle Creek			21.5		
	Left Fork	143, 9	3.0		1.0	40
	Indian Creek	129, 3	34.2	43.9	15.0	55
	Clear Fork Creek	121, 19	22.0	145.9	9.0	64
	Laurel Fork	121, 14, 6	47.0	58.9	20.0	84
	Little Huff Creek	110, 8	19.8	43.1	8.0	92
II	Guyandot River (below Baileysville, W. Va.)	119	504	1671	200	--

(Continued)

Table 1 (Con't.)

Plan No.	Location of Proposed Dam	Miles from Mouth Guyandot River	Drainage Area At Dam (sq.mi.)	Drainage Area At Mouth (sq.mi.)	Est. Increase (cfs)	Accum. Total Inc. (cfs)
III	Mud River (4 mi.) abv. Milton W. Va.)	8, 20	270	358	100	-
IV	Tommy Creek	162, 2	13.8	14.9	6	-
	Pinnacle Creek	144, 2	55.9	58.8	12	18
	Indian Creek	129, 3	34.2	43.9	8	26
	Laurel Fork	121, 14, 6	47.0	58.9	10	36
V	Tommy Creek	162, 2	13.8	14.9	6	-
	Pinnacle Creek	144, 2	55.9	58.8	12	18
	Indian Creek	129, 3	34.2	43.9	8	26
VI	Tommy Creek	162, 2	13.8	14.9	6	
	Pinnacle Creek	144, 2	55.9	58.8	6	12
	Indian Creek	129, 3	34.2	43.9	8	20
VII	Pinnacle Creek	144, 2	55.9	58.8	6	-
	Indian Creek	129, 3	34.2	43.9	8	14

AUGMENTATION BENEFITS

AREAS BENEFITING BY ASSURED FLOW INCREASES

Although the total accumulated increases in flow from the ten proposed tributary reservoirs (Plan I) is about one-half of the increase estimated for the main stem reservoir (Plan II), it is apparent from the standpoint of relative populations affected that greater benefit to water supplies and pollution abatement would be derived from Plan I. It will also be shown that with less than one-half of the maximum augmentation proposed in Plan I similar benefits would be obtained. The relative monetary benefit to water supply and pollution abatement by the six upper basin plans and the Mud River plan are shown in a later section.

The communities that would benefit by the respective reservoir plans together with pertinent water supply and sewerage data are as follows:

Plan I - Benefiting Communities

Name of Community (West Virginia)	Pop. Served	Water Supply		Consump. (GPD)	Est. PE Dischgd.	Sewage Disposal	
		Source				Collect. System	No Collect. System
Rhodell	900	Well		50,000	450		X
Amego	500	Well-Mine		30,000	250		X
Stephenson	350	Mine		20,000	175		X
Allen	360	Mine		32,000	180		X
Beechwood	175	Mine		10,000	90		X
Corrine	450	Well		25,000	450	X	
Black Eagle	300	Well		20,000	150		
Mullens	4,120	Well-Cr.		225,000	2,100	X	
Herndon	200	Well		10,000	100		
Bud	350	Well		25,000	175		
Alpoca	900	Well-Sprg.		55,000	450		X
Tralee	225	Well		15,000	100		X
Itman	950	Well		60,000	475		X
New Richmond	500	Well		30,000	250		X
Pineville	2,500	Creek		110,000	1,800	X	
Mullensville	250	Well		15,000	125		
Glover	200	Well		15,000	100		X
Wyoming	400	Well-Mine		25,000	200		X
Marianna	300	Well		20,000	150		X
Brenton	400	Well		25,000	200		X
Baileysville	875	Well		50,000	425		X
Jesse	200	Well		10,000	100		X
Oceana	1,960	Creek		100,000	200		
Clearfork	400	Well		25,000	200	X	
Simon	250	Well		15,000	125		X
Justice	150	Well		10,000	75		X
Gilbert	1,000	Well		60,000	500		X
Tamcliff	400	Well		25,000	200		X
Landville	300	Well		20,000	150		X
Christian	350	Well		20,000	175		X
Man	1,900	River		180,000	1,500	X	

Plan I - Benefiting Communities (Con't.)

Name of Community (West Virginia)	Pop. Served	Water Supply		Consump. (GPD)	Sewage Disposal		
		Source			Est. PE Dischgd.	Collect. System	No Collect. System
Earling	1,000	River		60,000	500		X
Rita	300	Well		20,000	150		X
Dabney	250	Mine		15,000	125		X
Stollings and McConnell	2,000	Logan		---	2,000	X	
Logan (Metro.)	20,000	River		1,100,000	20,000	X	
Big Creek	450	Well		25,000	225		X
Harts	220	Well		10,000	110		XX
Renger	500	Well		30,000	250		X
Midkiff	300	Well		15,000	150		X
Branchland	520	Well		25,000	260		XX
West Hamlin	790	Well		45,000	400		X
Barboursville	---	Huntington		---	1,600	X	
Huntington	---	Ohio River		---	15,000	X	
Totals	48,425			2,677,000	57,390		

Plan II - Benefiting Communities

Name of Community (West Virginia)	Pop. Served	Water Supply		Consump. (GPD)	Sewage Disposal		
		Source			Est. PE Dischgd.	Collect. System	No Collect. System
Justice	150	Well		10,000	75		X
Gilbert	1,000	Well		60,000	500		X
Tamcliff	400	Well		25,000	200		X
Landville	300	Well		20,000	150		X
Christian	350	Well		20,000	175		X
Man	1,900	River		180,000	1,500	X	
Earling	1,000	River		60,000	500		X
Rita	300	Well		20,000	150		X
Dabney	250	Mine		15,000	125		X
Stollings and McConnell	2,000	Logan		-----	2,000	X	
Logan (Metro.)	20,000	River		1,100,000	20,000	X	
Big Creek	450	Well		25,000	225		X
Harts	220	Well		10,000	110		X
Ranger	500	Well		30,000	250		X
Midkiff	300	Well		15,000	150		X
Branchland	520	Well		25,000	260		X
West Hamlin	790	Well		45,000	400		X
Barboursville	-----	Huntington		-----	1,600	X	
Huntington	-----	Ohio River		-----	15,000	X	
Totals	30,430			1,660,000	43,370		

Plan III - Benefiting Communities

Name of Community (West Virginia)	Pop. Served	Water Supply		Consump. (GPD)	Est. PE Dischgd.	Sewage Disposal	
		Source				Collect. System	No Collect. System
Milton	3,400	River		215,000	1,900	X	
Barboursville	---	Huntington		---	1,600	X	
Huntington	---	Ohio River		---	15,000	X	
Totals	3,400			215,000	18,500		

For water supply considerations Plan IV would affect all communities listed above for Plan I except Herndon. Plans V and VI would affect all communities listed for Plan I except Herndon, Oceana, Clearfork, and Simon. Plan VII would eliminate the following from those listed for Plan I: Rhodell, Amego, Stephenson, Allen, Beechwood, Corrine, Black Eagle, Mullens, Herndon, Bud, Alpoca, Tralee, Itman, New Richmond, Oceana, Clearfork, and Simon. For pollution abatement or stream quality evaluations all communities listed for Plan I are considered in the seven plans since wastes from each contribute to reduced water quality in stream sections where increased flows are proposed. For example, Plan VII would provide increased flows from Pinnacle Creek which enters the main stem Guyandot River downstream from many waste sources. The accumulated waste loads carried in the main stem Guyandot River from upstream sources with allowances for assimilation between sources would become a part of total waste loads existing at points of additional loading downstream from Pinnacle Creek and therefore would be affected by the increased flow.

It is noted in the above tables that many small communities and coal camps exist on the portions of the Guyandot River and tributaries affected by the assured increased flows. Many of these water supplies are owned and operated by private companies and are of such small size that to install and maintain facilities for proper conditioning of either ground water or surface water for domestic use is economically unfeasible. There are, however, areas containing communities in close enough proximity of one another that a properly located water treatment

facility could serve several communities under the auspices of a public service district. An act of the 1953 Legislature of West Virginia authorizes county courts to establish public service districts for water supply or sewerage services in unincorporated areas. Benefits to such areas by assured increased flows together with benefits to cities presently possessing treatment facilities are shown in the section on water supply benefits.

Pollution abatement benefits by low flow augmentation can be derived for sections receiving excessive waste loads in relation to potential low flow conditions. For pollution abatement evaluation purposes, communities having no sewage collection system are considered to discharge sewage to the adjacent stream from individual residence facilities. As agreed by the State of West Virginia Water Commission, the waste loads from unsewered communities are considered to be 50 per cent of the estimated community population. Benefits to waste load assimilation by the assured increased flows are shown in the section on pollution abatement benefits.

WATER SUPPLY BENEFITS

Water supply benefits are based on costs involved in the use of the most economical alternate supply where shortages in existing supplies are reported, and on relative costs involved in the treatment of surface water as opposed to treatment of ground water at locations where the expense of treating low quality ground water would be reduced

by use of a portion of the assured increase in stream flow. Where a community single purpose reservoir is determined to be the alternate source of supply, the benefit assigned to low flow augmentation is equivalent to the cost and operation of such an installation.

Reservoir cost estimates used in the evaluations were obtained from the results of a study by Hazen on the cost of reservoirs in an Appalachian Mountain region.² Ground and surface water treatment costs applied in the evaluations were obtained from several communities of moderate size which deliver water of recommended standard quality for domestic use as obtained from both ground and surface water sources in the Guyandot Basin. It is assumed in the evaluations that water distribution costs would remain unchanged in event of conversion from ground water to surface water, and that the cost of intake lines would be relatively insignificant in view of the close proximity of existing water plants to the adjacent streams. In the case of new installations where adjoining communities would be served from a central water plant, the cost of connecting pipelines are included. All evaluations are made on the assumption that coal washery wastes are nonexistent in the surface waters as a result of the present West Virginia control regulations.

The following are consumer costs, as based on typical rates for treatment and delivery of water from ground and surface water sources in the Guyandot Basin:

Ground water containing ferrous iron and hydrogen sulfide	\$ 980 per million gallons
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Surface water devoid of coal washery wastes	\$ 550 per million gallons
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Plan I - Water Supply Benefits

There are three categories of water supply benefits to consider in assigning value benefits to the ten tributary reservoirs of Plan I. These categories are as follows:

1. Benefits derived from savings in water treatment costs by converting from low quality ground water to surface water in areas where natural low flows are inadequate and where increased minimum stream flows by project development are anticipated;
2. Benefits derived from savings in water treatment costs in areas where ground water is the most economical alternate source available to supplement existing surface sources experiencing supply shortages under natural low flow conditions;
3. Benefits to areas where a community reservoir is the only alternate source available to existing surface sources experiencing supply shortages.

The basic minimum flow required to sustain stream life and render the quality of surface water suitable for treatment by conventional methods for domestic use in demand areas down stream from the proposed reservoirs is 4.0 cfs. This assumes primary treatment of sewage with effluent chlorination for bacterial reduction and effluents containing no greater than 225 pounds of biochemical oxygen demand per day for maintenance of a 4.0 parts per million minimum dissolved oxygen level in the stream. These requirements are not met under the presently existing natural low flow conditions.

According to flow records given in an earlier section, a minimum flow of 3.0 second feet has been observed at the U.S.G.S. gauge at Man, West Virginia, many miles below the areas considered in the proposed reservoir plans. Much of the area becomes essentially dry during drought periods, as has been reported by upper basin communities, and because of several relatively large sources of raw sewage the quality of receiving stream water during low flow periods would be unsuited for domestic use. In order to realize full benefits to water supply by Plan I, it is assumed that coal washery wastes would be considerably reduced and that at least primary treatment with effluent chlorination would be provided at Mullens and Pineville. Communities that would benefit by assured stream flows as provided in Plan I, together with estimated cost benefits are as follows:

Category 1

(Ground water supplies with surface water alternate)

A. Group 1

<u>Name of Community (West Virginia)</u>	<u>Population Served</u>	<u>Annual Consumption (million gal.)</u>
Rhodell	900	18.2
Amego	500	11.0
Stephenson	350	7.5
Allen	360	11.6
Beachwood	175	4.0
Corrine	450	9.0
Black Eagle	300	7.0
Totals	3,035	68.3

Annual Costs:

Ground water - 68.3 x \$980 = \$ 66,900

Surface Water - 68.3 x \$550 = 37,500

29,400

Connecting Pipelines = 6,700

Annual Benefit = \$ 22,700

B. Group 2

<u>Name of Community (West Virginia)</u>	<u>Population Served</u>	<u>Annual Consumption (Million gal.)</u>
Herndon	200	4.0
Bud	350	9.1
Alpoca	900	20.0
Tralee	225	5.5
Itman	950	22.0
Totals	2,625	60.6

Annual Costs:

Ground water - 60.6 x \$980 = \$ 59,400

Surface Water - 60.6 x \$550 = 33,400

26,000

Connecting Pipelines = 13,000

Annual Benefit = \$ 13,000

C. Group 3

<u>Name of Community (West Virginia)</u>	<u>Population Served</u>	<u>Annual Consumption (million gal.)</u>
Mullensville	250	5.5
Glover	200	5.5
Wyoming	400	9.1
Marianna	300	7.3
Brenton	400	9.1
Baileysville	875	18.2
Totals	2,425	54.7

Annual Costs:

Ground Water - $54.7 \times \$980$	=	\$ 53,600
Surface Water - $54.7 \times \$550$	=	30,100
		<u>23,500</u>
Connecting Pipelines	=	12,000
Annual Benefit	=	\$ 11,500

D. Single Communities

<u>Name of Community (West Virginia)</u>	<u>Population Served</u>	<u>Annual Consumption (million gal.)</u>
Mullens	4,000	82.0
Gilbert*	1,000	21.8
Totals	5,000	103.8

Annual Costs:

Ground Water - $103.8 \times \$980$	=	\$ 101,700
Surface Water - $103.8 \times \$550$	=	57,100
Annual Benefit	=	\$ 44,600

* This community has no central water system at the present time.

Category 2

(Surface water supplies with ground water
as alternate source)

<u>Name of Community (West Virginia)</u>	<u>Population Served</u>	<u>Annual Consumption (million gal.)</u>
Pineville	1,200	40.0
Oceana	1,960	36.5
Man	1,900	65.8
Earling	<u>1,000</u>	<u>22.9</u>
Totals	6,060	165.2

Annual Costs:

Ground Water - 165.2 x \$980	=	\$ 161,900
Surface Water - 165.2 x \$550	=	<u>90,900</u>
Annual Benefit		\$ <u>71,000</u>

Category 3

(Surface water supplies with a
reservoir as alternate)

<u>Name of Community (West Virginia)</u>	<u>Population Served</u>	<u>Design Consumption MGD</u>
Logan (Metro)	22,000	2.0

Design Capacity - 200 million gallons

Cost per million gallons - \$2,000

Cost of reservoir

Interest @ 4.5% (50 years)

Total capital investment

Annual charge

Annual operation

Annual Benefit

=	\$ 400,000
=	<u>460,000</u>
	860,000
	17,200
	<u>5,500</u>
\$	<u>22,200</u>

Summary of Plan I, Water Supply Benefits

<u>Category No.</u>	<u>Annual Benefits</u>
1	
2	\$ 91,800
3	71,000
	<u>22,200</u>
Annual Project Benefit*	\$ 185,000

* In case that water storage permits only one-half of the estimated maximum increases in flow, items A and B, Category 1, should be omitted because of the unsuitability of quality for domestic use.

Plan II, Water Supply Benefits

Category 1 (Ground water supplies with surface water as alternate)

See Plan I, Category 1, Item D (Gilbert)
Annual Benefit - \$ 9,400

Category 2 (Surface water supply with ground water as alternate source)

See Plan I, Category 2
Annual Benefit - \$ 71,000

Category 3 (Surface water supplies with a reservoir as alternate)

See Plan I, Category 3
Annual Benefit - \$22,500

Summary of Plan II, Water Supply Benefits

<u>Category No.</u>	<u>Annual Benefits</u>
1	
2	\$ 9,400
3	71,000
	<u>22,200</u>
Annual Project Benefit*	\$ 102,000

* This figure would also apply to increases in flow amounting to one-half of the estimated maximum increase.

Plan III, Water Supply Benefits

The community of Milton, West Virginia, is the only major community on the Mud River to benefit by assured increases in flow from this proposed reservoir site. Ground water is not considered as an alternate source due to its reported high salt content. A reservoir is, therefore, the alternate source of water for this community. The estimated cost of a reservoir of the size needed and the average annual cost benefit is as follows:

Design capacity of reservoir - 40 million gallons	
Cost per million gallons - \$ 2,500	
Cost of reservoir	\$ 100,000
Interest @ 4.5% (50 years)	114,750
Total capital investment	214,750
Annual charge	4,300
Annual operation	3,000
Annual benefit	\$ 7,300*

* This benefit would also apply to increases in flow amounting to one-half of the estimated maximum increase.

Plan IV, Water Supply Benefits

Nearly all of the communities benefiting by Plan I are included in Plan IV. The flow increases specified are sufficient to supply all of the requirements. Following are the benefits associated with specific reservoirs included in this plan:

<u>Proposed Reservoir</u>	<u>Communities or Plan I Reference</u>	<u>Annual Benefits</u>
Tommy Creek	Group 1, page 31	\$ 22,700
" "	Mullens	35,300
" "	Group 2, page 31 (excludes Herndon and considers pipe- line changes)	17,000
	Total	75,000
Pinnacle Creek	Pineville	\$ 17,000
	Group 3, page 32	11,500
	Total	\$ 28,500
Indian Creek	Gilbert, Man and Earling	\$ 47,500
	Logan	22,200
	Total	\$ 69,700
Laurel Fork	Oceana	\$ 15,700
	Total	\$ 15,700
Annual Project Benefit		\$ 189,100

Plan V, Water Supply Benefits

This plan is similar to Plan IV except that the Laurel Fork Reservoir is left out.

Annual Project Benefit \$ 173,400

Plan VI, Water Supply Benefits

This plan is similar to Plan V except that the flow increase from Pinnacle Creek Reservoir is reduced by one-half; i.e., 12 cfs to 6 cfs.

With increases of 6 cfs from Tommy Creek, 6 cfs from Pinnacle Creek, and 8 cfs from Indian Creek, sufficient flow is provided for water supply purposes at locations shown for Plan V.

Annual Project Benefit \$ 173,400

Plan VII, Water Supply Benefit

By eliminating the Tommy Creek Reservoir all communities above Pineville are omitted from water supply benefits. The increased flows proposed from Pinnacle Creek and Indian Creek are of sufficient volume to meet water supply requirements downstream from the respective reservoirs. Following are the benefits associated with the two reservoirs included in this plan:

<u>Proposed Reservoir</u>	<u>Communities or Plan I Reference</u>	<u>Annual Benefits</u>
Pinnacle Creek	Pineville	\$ 17,200
	Group 3, page 32	<u>11,500</u>
		\$ 28,700
Indian Creek	Gilbert, Man and Earling	\$ 47,500
	Logan	<u>22,200</u>
	Total	\$ 69,700
Annual Project Benefit		\$ 98,400

POLLUTION ABATEMENT BENEFITS

The design flow used for pollution abatement computations in West Virginia is established as the minimum average seven-day flow with a return period of ten years. The design flow calculated for the Guyandot River at Man, West Virginia, is 15 cfs and for the Mud River near Milton, West Virginia, 0.8 cfs.

The total flow at these gauging points on the Guyandot and Mud Rivers, including the estimated maximum flow increases for Plans I through VII are given below.

<u>Plan No.</u>	<u>Design Flow(cfs)</u>	<u>Augmentation Flows(cfs)</u>	<u>Total Flow(cfs)</u>
I	15	92*	107
II	15	200*	215
III	0.8	100*	100.8
IV	15	36	51
V	15	26	41
VI	15	20	35
VII	15	14	29

* Also one-half these amounts.

Waste loads used in the computations are those listed in the section dealing with areas benefiting by assured flow increases (page 21).

Low flow augmentation benefits can be derived for stream sections which receive waste loads in excess of maximum design loading. Therefore, augmentation value is dependent on the magnitude of the design low flow (minimum 7-day average low flow with ten year return period), assimilative capacity of the stream during low flow periods, amount of BOD₅ received in the stream and amount and assimilative capacity of the increased flow.

Benefits cannot, by PHS policy, be assigned to abatement of raw sewage by low flow augmentation. Where wastes are not treated it is assumed for computation purposes that at least primary treatment of wastes is applied before discharge to the stream. In general, pollution abatement benefits are not assigned where low flow augmentation would substitute for sewage treatment works required by State or local authorities or contemplated in comprehensive pollution control plans prepared under the Federal Water Pollution Control Act.

At the present time the West Virginia Water Commission requires primary treatment of wastes in the Guyandot Basin. At some future time when multi-community organizations develop or water uses change, it is assumed that secondary treatment will be required.

For purposes of evaluating pollution abatement benefits in the Guyandot River Basin, fifteen years credit is given for assimilation of excess waste loads from primary treatment and thirty-five years credit for assimilation of excess waste loads from secondary treatment.

Benefits applied to augmentation are based on equivalent costs to remove each pound of the excess BOD_5 per day per year by conventional means.

Plan I, Pollution Abatement Benefits

Design flows assigned to the various tributaries for waste load assimilation evaluations together with assured flows involved in Plan I are given in Table 2.

Table 2

**Tributary Design Flows and Proposed Project Flow Increases
Plan I, Guyandot River**

Tributary Name	Design Flow (cfs)	Cumulative Totals (cfs)	Flow Increases (cfs)	Cumulative Totals (cfs)
Winding Gulf Creek	0.94	0.94	---	0.94
Stone Coal Creek	0.24	1.18	---	1.18
Tommy Creek	0.30	1.48	6.0	7.48
Main Stem	0.30	1.78	---	7.78
Slab Fork Creek	0.60	2.38	---	8.38
Barkers Creek	0.74	3.12	7.0	16.12
Main Stem	0.45	3.57	---	16.57
Cabin Creek	0.26	3.83	3.0	19.83
Main Stem	0.39	4.22	---	20.22
Pinnacle Creek	1.15	5.37	23.0	44.37
Rockcastle Creek	0.42	5.79	1.0	45.37
Main Stem	1.12	6.91	---	46.91
Indian Creek	0.87	7.78	15.0	62.78
Clear Fork Creek	1.70	9.48	9.0	73.48
Laurel Fork	1.15	10.63	20.0	94.63
Main Stem	0.65	11.28	---	95.28
Little Huff Creek	0.84	12.12	8.0	104.12
Main Stem	1.76	13.88	---	105.88
Huff Creek	1.12	15.00	---	107.00

Table 2 (Con't.)

Tributary Design Flows and Proposed Project Flow Increases
Plan I, Guyandot River

Tributary Name	Design Flow (cfs)	Cumulative Totals (cfs)	Flow Increases (cfs)	Cumulative Totals (cfs)
Branchland	12.00	27.00	---	134.00
Main Stem	1.90	28.90	---	135.90
Mud River	0.80	29.70	---	136.70
Huntington	0.20	29.90	---	136.90

Calculations, using standard stream assimilation procedures, show that the ultimate BOD cannot exceed 13.5 ppm ($BOD_5 = 11.5$), if a minimum dissolved oxygen concentration of 4.0 ppm is to be maintained in all sections of the stream. Table 3 shows the calculated maximum allowable BOD loads corresponding to design and augmented flows for the respective reaches of the Guyandot River and tributaries involved in Plan I. Ultimate BOD loads are used throughout for convenience in computing waste load assimilations by use of the exponential equation $y = L (1 - 10^{-kt})$ where (y), the demand exerted at time (t), is a function of the ultimate demand (L), the rate of oxidation (k), and the time interval (t).

Table 3

Maximum Allowable Ultimate BOD Loads to Maintain 4.0 ppm Dissolved Oxygen
Plan I, Guyandot River

Load Sections	Natural Conditions		Augmented		1/2 Augmented	
	Design Flow (cfs)	Max. Allow. BOD (lbs.)	Flow (cfs)	Max. Allow. BOD (lbs.)	Max. Allow. BOD (lbs.)	BOD (lbs.)
Tommy Cr. to Stone Coal Cr.	1.78	130	7.78	560		350
Stone Coal Cr. to Barkers Cr.	2.38	175	8.38	610		400
Barkers Creek	0.74	55	7.74	560		310
Cabin Cr. to Pinnacle Cr.	3.57	260	19.83	1,450		850
Pinnacle Cr. to Rockcastle Cr.	5.37	390	44.37	3,200		1,800
Rockcastle Cr. to Indian Cr.	7.78	570	46.91	3,400		1,950
Indian Cr. to Clear Fork Cr.	9.48	720	62.78	4,500		2,550
Laurel Fork of Clear Fork Cr.	1.50	110	21.15	1,540		810
Clear Fork Cr. to Little Huff Cr.	12.12	890	95.28	6,950		3,900
Little Huff Cr. to Huff Cr.	13.88	1,000	104.12	7,600		4,500

Table 3 (Con't.)

Maximum Allowable Ultimate BOD Loads to Maintain 4.0 ppm Dissolved Oxygen
Plan I, Guyandot River

Load Sections	Natural Conditions		Augmented		1/2 Augmented
	Design Flow (cfs)	Max. Allow. BOD (lbs.)	Flow (cfs)	Max. Allow. BOD (lbs.)	Max. Allow. BOD (lbs.)
Huff Cr. to Buffalo Cr.	15.00	1,100	107.00	7,800	3,900
Buffalo Cr. to Island Cr.	16.00	1,170	108.00	7,900	3,950
Logan (Metropolitan)	18.00	1,300	110.00	8,000	4,000
Mouth of Mud River	28.90	2,100	120.90	8,900	4,450
Huntington	29.90	2,200	132.00	9,600	4,800
POSSIBLE CREEK	0.47	22	1.47	200	370
FAIRFAX CR.	5.29	712	9.79	810	400
SPRING CREEK CR.	7.49	170	1.42	200	220
TOTAL DISCHARGE	100.00 (cfs)	2,100 (lbs.)	300.00 (cfs)	200 (lbs.)	BOD (lbs.)
	DESIGN FLOW	DESIGN FLOW	DESIGN FLOW	DESIGN FLOW	DESIGN FLOW
	DESIGN FLOW	DESIGN FLOW	DESIGN FLOW	DESIGN FLOW	DESIGN FLOW

PLAN I - DRAINAGE STAGE

MAXIMUM ALLOWABLE ULTIMATE BOD LOADS TO MAINTAIN 4.0 PPM DISSOLVED OXYGEN

1976

Listed in Table 4 are the cumulative waste loads that would occur in the various stream sections after the application of primary and secondary treatment of wastes at all sources. Comparing the maximum allowable BOD loads shown in Table 3 with the computed stream loads shown in Table 4 reveal that greater than maximum allowable loads would occur during low flow periods at the following locations on the main stem Guyandot River: Rhodell to the mouth of Clear Fork Creek; below Baileysville; at Logan; and at Huntington. Design waste loads are also exceeded in Barkers Creek and in Clear Fork Creek downstream from the mouth of Laurel Fork Creek.

Table 5 shows the various stream sections and corresponding waste loads that are assignable to increased flows proposed in Plan I. The value of the increased flow in terms of the difference in cost between primary and secondary treatment (1960 costs) involved in removing or assimilating the amount of BOD shown in Table 5 are listed according to creditable time periods in Table 6.

Table 4

Computed Ultimate BOD Loads for Stream Sections
to which Proposed Flow Increases are Applied
Plan I, Guyandot River

Load Section	Stream Load Pounds Ultimate BOD Per Day	
	Primary Treatment	Secondary Treatment
Tommy Creek to Stone Coal Creek	280	130
Stone Coal Creek to Barkers Creek	610	375
Barkers Creek	120	45
Barkers Creek to Cabin Cr.	820	530
Cabin Creek to Pinnacle Cr.	740	480
Pinnacle Creek to Rockcastle Creek	960	640
Rockcastle Creek to Indian Creek	940	660
Indian Creek to Clear Fork Cr.	1,000	680
Laurel Fork	180	70
Clear Fork Creek to Little Huff Creek	1,100	790
Little Huff Creek to Huff Creek	830	580
Huff Creek to Buffalo Creek	1,000	650
Buffalo Cr. to Island Cr.	1,300	780
Logan, West Virginia	4,500	1,950
Huntington, West Virginia	3,650	2,000

Table 5

Waste Load Assimilation Assigned to
Low Flow Augmentation
Plan I, Guyandot River

Load Section from Table 3	Stream Load Ultimate BOD(lbs)		Load Assigned to Max. Aug.		Augmentation 1/2 Aug.	
	Prim.	Sec.	Prim.	Sec.	Prim.	Sec.
Tommy Creek to Slab Fork Creek	280	130	150	None	150	None
Slab Fork Creek to Barkers Creek	610	375	300	200	100	200
Barkers Creek	120	45	65	None	65	None
Barkers Creek to Pinnacle Creek	960	640	100	50	100	50
Laurel Fork of Clear Fork Creek	180	70	70	None	70	None
Logan (Metropolitan)	4,500	1,950	3,200	650	2,700	650
Huntington	3,650	2,000	1,450	None	1,450	None

Table 6

Low Flow Augmentation Benefits by
Time Periods, Plan I, Guyandot River

<u>Load Section</u>	<u>Full Augmentation</u>		<u>1/2 Augmentation</u>	
	<u>1960-1975</u>	<u>1976-2010</u>	<u>1960-1975</u>	<u>1976-2010</u>
Tommy Creek to Stone Coal Cr.	\$ 36,000	None	\$ 36,000	None
Stone Coal Creek to Barkers Cr.	72,000	\$ 112,000	26,500	\$ 112,000
Barkers Creek	15,500	None	15,500	None
Barkers Creek to Pinnacle Cr.	24,000	28,000	24,000	28,000
Laurel Fork of Clear Fork Cr.	17,000	None	17,000	None
Logan	770,000	365,000	650,000	365,000
Huntington	350,000	None	350,000	None
Sub Totals	\$1,284,500	\$ 505,000	\$1,119,000	\$ 505,000
Project Benefit*	\$1,789,500		\$1,624,000	

* Without Mud River augmentation.

The project benefit assignable to Plan I with full augmentation is \$1,789,500 and with one-half augmentation from all sites, \$1,624,000. The major difference in benefits between full and one-half augmentation lies at Logan where with primary treatment, one-half augmentation by Plan I is 5.5 cfs short of obtaining full benefit. With secondary treatment at Logan, one-half augmentation provides 27 cfs more than would be required to raise the stream water quality to the minimum objective. After the year 1975, flow increases of greater than 8 cfs at Logan and 0 cfs at Huntington would have a potential benefit of \$1,000 per cfs based on 1960 costs.

Plan II, Pollution Abatement Benefits

Owing to the particular location of the reservoir proposed for the main stem of the Guyandot River, Plan II, four of the upstream sections benefited in Plan I are eliminated. Pollution abatement benefits assignable to Plan II would therefore be at Logan and Huntington. The estimated maximum low flow increase of 200 cfs from this reservoir site would abate downstream pollution far in excess of that needed to control dissolved oxygen levels at a minimum of 4.0 ppm. At one-half of this flow, dissolved oxygen levels would also be controlled above 4.0 ppm as can be seen in Table 3, Buffalo Creek to Island Creek. The apportionate benefits assignable to pollution abatement for both maximum and one-half maximum augmentation by Plan II are shown in Table 7.

Table 7

Low Flow Augmentation Benefits by
Time Periods, Plan II, Guyandot River

Load Section	Full Augmentation		1/2 Augmentation	
	1960-1975	1976-2010	1960-1975	1976-2010
Logan	\$ 770,000	\$ 365,000	\$ 770,000	\$ 365,000
Huntington	350,000	None	350,000	None
Sub Totals	\$1,120,000	\$ 365,000	\$1,120,000	\$ 365,000
Project Benefit*	\$1,485,000		\$1,485,000	

* Without Mud River augmentation.

Plan III, Pollution Abatement Benefits

An assured low flow increase in Mud River during low flow periods would significantly improve the quality of the river at three locations downstream from the proposed reservoir site. Table 8 shows the calculated maximum allowable BOD loads corresponding to minimum design flows and augmented flows for the reaches for which benefits are evaluated.

Table 8

Maximum Allowable Ultimate BOD Loads to Maintain
4.0 ppm Dissolved Oxygen, Plan III, Mud River

Source of Load	Design Flow (cfs)	Max. Allow. BOD (lbs.)	Aug. Flow (cfs)	Max. Allow. BOD (lbs.)
Milton	0.8	60	100.8	7,800
Barboursville	1.0	70	101.0	8,000
Huntington	30.0	2,200	130.0	9,500

Both the 100 cfs and 50 cfs increase in flow provides assimilative capacity far in excess of that required to maintain 4.0 ppm dissolved oxygen in the stream under design low flow conditions. The waste loads assignable to augmentation on the Mud River are shown in Table 9.

Load Section	1960-1975	1976-2010	1960-1975	1976-2010
Milton	\$ 93,000	\$ 54,500	\$ 93,000	\$ 54,500
Barboursville	12,000	12,000	12,000	12,000
Huntington	350,000	350,000	350,000	350,000
Sub Totals	\$ 455,000	\$ 216,500	\$ 455,000	\$ 216,500
Project Benefits	\$ 425,000	\$ 216,500	\$ 425,000	\$ 216,500

* Without upper basin augmentation.

Table 9

Waste Load Assimilation Assigned to Low Flow
Augmentation, Plan III, Mud River

Load Section from Table 8	Stream Load Ultimate BOD (lbs)		Load Assigned to Augmentation			
	Prim.	Sec.	Max. Aug.		1/2 Aug.	
			Prim.	Sec.	Prim.	Sec.
Milton	450	175	390	115	390	115
Barboursville	510	210	60	35	60	35
Huntington	3,650	2,000	1,450	None	1,450	None

The apportionate benefits assignable to pollution abatement for both maximum and one-half maximum augmentation by Plan III are shown in Table 10.

Table 10

Low Flow Augmentation Benefits by Time Periods,
Plan III, Mud River

Load Section	Full Augmentation		1/2 Augmentation	
	1960-1975	1976-2010	1960-1975	1976-2010
Milton	\$ 93,000	\$ 64,500	\$ 93,000	\$ 64,500
Barboursville	15,000	19,600	15,000	19,600
Huntington	350,000	None	350,000	None
Sub Totals	\$458,000	\$ 84,100	\$458,000	\$ 84,100
Project Benefit*	\$542,100		\$542,100	

* Without upper basin augmentation.

Plan IV, Pollution Abatement Benefits

The increased flow provided by this plan is sufficient to satisfy needs for improved stream quality between Rhodell and Pineville and can be credited for maximum benefits attainable in this area.

The total increase from the three reservoirs (36 cfs) with primary treatment would be 6 cfs less than that required to obtain full benefit at Logan and 16 cfs more than that required at Huntington. After the year 1975, with secondary treatment, there would be 28 cfs at Logan and 36 cfs at Huntington to which direct benefits cannot be assigned but which would improve the quality of the stream over and above minimum objectives. Such excess flow would have a potential value of \$1,000 per cfs based on 1960 costs. Benefits assignable to pollution abatement by Plan IV are shown in Table 11.

Table 11

Low Flow Augmentation Benefits by
Time Periods, Plan IV, Guyandot River

<u>Proposed Reservoir</u>	<u>Benefit 1960-1975</u>	<u>Benefit 1976-2010</u>
Tommy Creek		
Rhodell to Pineville	\$ 108,000	\$ 112,000
Logan	108,000	61,000
Huntington	48,000	None
Pinnacle Creek		
Pineville to Baileysville	24,000	28,000
Logan	216,000	122,000
Huntington	115,000	None
Indian Creek		
Baileysville to Logan	None	None
Logan	144,000	80,000
Huntington	77,000	None
Laurel Fork		
Oceana	17,000	None
Logan	82,000	102,000
Huntington	100,000	None
Sub Totals	\$1,039,000	\$ 505,000
Project Benefit*		\$1,544,000

* Without Mud River augmentation.

Plan V, Pollution Abatement Benefits

This plan provides sufficient increased flow between Rhodell and Pineville to raise the stream quality to minimum objectives and to be credited with the maximum benefit attainable in this area.

The total increase from the three reservoirs (26 cfs) with primary treatment, would be 16 cfs less than that required to obtain full benefit at Logan and 6 more than that required at Huntington. After the year 1975, with secondary treatment, there would be 18 cfs at Logan and 26 cfs at Huntington to which direct benefits cannot be assigned but which would improve the quality of the stream over and above minimum objectives.

Such excess flow would have a potential value of \$1,000 per cfs based on 1960 costs. Benefits assignable to pollution abatement by Plan V are shown in Table 12.

Table 12

Low Flow Augmentation Benefits by
Time Periods, Plan V, Guyandot River

<u>Proposed Reservoir</u>	<u>Benefit 1960-1975</u>	<u>Benefit 1976-2010</u>
Tommy Creek		
Rhodell to Pineville	\$ 108,000	\$ 112,000
Logan	105,000	84,000
Huntington	80,000	None
Pinnacle Creek		
Pineville to Baileysville	24,000	28,000
Logan	210,000	113,000
Huntington	162,000	None
Indian Creek		
Baileysville	None	None
Logan	140,000	168,000
Huntington	108,000	None
Sub Totals	\$ 937,000	\$ 505,000
Project Benefit*		\$1,442,000

* Without Mud River augmentation.

Plan VI, Pollution Abatement Benefits

This plan provides sufficient increased flow between Rhodell and Pineville to raise the stream quality to minimum objectives and to be credited with the maximum benefit attainable in this area.

The total increase from the three reservoirs (20 cfs) with primary treatment, would be 22 cfs less than that required to obtain full benefit at Logan and exactly enough required for full benefit at Huntington. After the year 1975, with secondary treatment, there would be 12 cfs at Logan and 20 cfs at Huntington to which direct benefits cannot be assigned but which would improve the quality of the stream over and above minimum objectives. Such excess flow would have a potential value of \$1,000 per cfs based on 1960 costs. Benefits assignable to pollution abatement by Plan VI are shown in Table 13.

Table 13

**Low Flow Augmentation Benefits by
Time Periods, Plan VI, Guyandot River**

<u>Proposed Reservoir</u>	<u>Benefit 1960-1975</u>	<u>Benefit 1976-2010</u>
Tommy Creek		
Rhodell to Pineville	\$ 108,000	\$ 112,000
Logan	111,000	110,000
Huntington	105,000	None
Pinnacle Creek		
Pineville to Baileysville	24,000	28,000
Logan	111,000	110,000
Huntington	105,000	None
Indian Creek		
Baileysville to Logan	None	None
Logan	148,000	145,000
Huntington	140,000	None
Sub Totals	\$ 852,000	\$ 505,000
Project Benefit*		\$1,357,000

* Without Mud River augmentation.

Plan VII, Pollution Abatement Benefits

This plan provides for no improvement in stream quality between Rhodell and Pineville. With primary treatment of wastes at all sources between Rhodell and Pineville including Pineville, the augmenting flow from Pinnacle Creek would be 1.5 cfs less than that required to obtain full benefit downstream from Pineville. However, with secondary treatment in these areas, augmenting flows from Pinnacle Creek would provide 3 cfs more than required for full benefit.

The total increase from the two reservoirs (14 cfs) with primary treatment, would provide 28 cfs less than that required to obtain full benefit at Logan and 6 cfs less than required at Huntington. However, after the year 1975, with secondary treatment, requirements would be exceeded at Logan and Huntington by 6 cfs and 14 cfs, respectively. Increased flows greater than required would have no assignable benefit but would improve the quality of the stream over and above minimum objectives and have potential benefits of \$1,000 per cfs based on 1960 costs. Benefits assignable to pollution abatement by Plan VII are shown in Table 14.

Table 14

**Low Flow Augmentation Benefits by
Time Periods, Plan VII, Guyandot River**

<u>Proposed Reservoir</u>	<u>Benefit 1960-1975</u>	<u>Benefit 1976-2010</u>
Pinnacle Creek		
Pineville to Baileysville	\$ 110,000	\$ 140,000
Logan	125,000	157,000
Huntington	107,000	None
Indian Creek		
Baileysville to Logan	None	None
Logan	165,000	208,000
Huntington	143,000	None
Sub Totals	\$ 650,000	\$ 505,000
Project Benefit*	\$1,155,000	

* Without Mud River augmentation.

DISCUSSION

Most of the small communities and mining towns in the Guyandot Basin are served by company or private water supplies which obtain water from wells and abandoned mines. The City of Logan and several smaller incorporated communities obtain raw water from adjacent streams. The quality of the ground water in most areas of the basin is unsuited for domestic use due to the high content of sulfides and iron. Because of this, the West Virginia Department of Health has urged many communities to seek new sources of better quality water. Surface waters appear to be the only alternate source of water in most of these areas. Except for the occasional high suspended solids content of stream waters from coal washery operations and raw sewage pollution from Mullens and Pineville, stream water is suitable in quality as a raw water source and can be economically treated for domestic use by conventional treatment methods.

It is not economically feasible for many communities as individuals to install and operate the type of facility required to properly treat ground water for sulfides and iron removal nor to treat surface water by conventional treatment methods. For this reason it is recommended that

groups of communities which are located within distances of 10 to 12 miles and which have combined populations of 3,000 or more cooperate to provide treatment facilities and distribution systems designed to serve all requirements within such community groups or districts. An enabling Act of the 1953 Legislature of West Virginia authorizes county courts to establish public service districts for water supply or sewerage services in unincorporated areas.

Since ground water supplies (wells and abandoned mines) are believed insufficient in quantity to meet water district requirements and are unsuited in quality for economic treatment and use for domestic purposes, surface water offers the only alternate source for such district supplies.

Under natural low flow conditions, however, stream flows in areas where water is needed are not of dependable volume to meet water supply requirements. This condition exists in areas from the headwaters of the Guyandot River downstream to and including Logan, West Virginia, and in Mud River in the vicinity of Milton, West Virginia.

The areas where improvements are needed, together with specific requirements and benefits to water supplies by proposed plans for assured increases in low flow are given in prior sections of this report. Generally, the communities in need of improved and dependable water supplies are located along the main stem of the Guyandot River from Logan upstream to the headwaters and along several tributary streams above Logan. Improvements are also needed along Mud River in the vicinity of Milton.

The present discharge of inadequately treated wastes in the Guyandot Basin impairs the quality of stream waters and tends to create a hazard to the health of persons in contact with these waters downstream from waste sources. Conditions unsuitable for normal fish and other aquatic life have also been created.

Considerable improvements in stream water quality and sanitation would be accomplished by waste treatment at locations where relatively large waste loads are received. Waste treatment should include effluent chlorination to reduce bacterial contamination of downstream waters.

It is found from computations involving waste loads (biochemical oxygen demand) and design low flows that even with waste treatment at all sources, the dissolved oxygen content at several points in the Guyandot River and tributaries would reduce to less than the minimum objective of 4.0 ppm. In such instances and at these various locations low flow augmentation would improve the stream quality, protect fishlife and aquatic environment, and prevent the occurrence of possible odor nuisances. Benefits assigned to these improvements from low flow augmentation in combination with degrees of BOD removed by treatment for specified time periods are shown in preceding sections of this report.

Various areas in the Guyandot Basin offer excellent locations for industrial sites. Assured increases in stream flows during low flow periods could be invaluable in promoting municipal and industrial growth. For example, shortages of water for power production have occurred at

Logan, West Virginia. It is reported that the Appalachian Power Company at Logan has had to curtail production during extreme low flow periods. Although significant benefits to power production appear to exist, no attempt to evaluate these is made at this time.

Should fishlife be restored and improved stream water quality obtained, significant recreational values may also be realized.

Depending upon future trends not now apparent in the Guyandot Basin, future growths in population and industrial activity may create greater demands for water than are considered in this report. It was chosen not to consider future increases in population or per capita water uses because of reports indicating actual reductions in populations and personal incomes due to mechanization of mining operations in the Guyandot Basin. Perhaps the 1960 Census will provide information relative to future population expectations.

Any increase in flow to the Ohio River during low flow periods would provide intangible benefit in terms of improved quality over and above minimum objectives and would have a small tangible benefit resulting from reductions in the use of chemicals required for treatment of water and wastes in the Cincinnati-Covington area.

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